7-7-2022

Initiation of Procalcitonin Screening as a Marker in Antibiotic Therapy De-escalation

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A Dissertation Submitted to The Graduate School at the University of Missouri- St. Louis
in partial fulfillment of the requirements for the degree
Doctor of Nursing Practice
with an emphasis as a Family Nurse Practitioner

August
2022

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Abstract

Problem: The overuse of antibiotics has created antimicrobial resistance (AMR) resulting in treatment failure for bacterial infections. To combat AMR, clinicians should only prescribe antibiotic therapy when clinically warranted. It is easy to misdiagnose a viral infection. However, any delay in the initiation of antibiotic therapy in a bacterial infection may lead to increased morbidity and mortality. These patients with non-specific clinical symptoms may be misdiagnosed without a rapid and definitive diagnostic test.

Methods: This quality improvement (QI) initiative utilized an evidence-based clinical guideline for procalcitonin (PCT) levels for antibiotic therapy de-escalation. WBC counts were collected two-days and one-day before ID work-up along with PCT levels and white blood cell (WBC) counts collected on day-1, day-3, and day-5 post infectious disease. Data was collected via prospective chart review including the number of positive PCT levels obtained versus positive cultures, average length of antibiotic use, number of different antibiotics used, and the time until the bacterial infection was confirmed or denied.

Results: The implemented PCT clinical guideline allowed for faster identification of bacterial infections than standard blood cultures. There is significant evidence supporting a positive relationship between elevated PCT levels and positive cultures. Over time the level of PCT decreases showing a correlation with a reduction of the WBC count.

Implications for Practice: Use of the PCT clinical guideline can identify whether there is a bacterial infection rapidly allowing for the initiation or de-escalation of antibiotic therapy preventing further AMR resistance.

Initiation of Procalcitonin Screening as a Marker in Antibiotic Therapy De-escalation

Overview

The increase in bacterial resistance to antibiotics is a global health concern (Ventola, 2015). In 1928 Alexander Fleming discovered the first antibiotic- penicillin, radically affecting treatment and mortality rates of many diseases such as pneumonia, gonorrhea, and rheumatic fever. Over the last nine decades, more than 100 different antibiotics were developed, resulting in increased cure rates of bacterial infections. However, through overuse of antibiotics in the healthcare system and the agricultural industry this has created antimicrobial resistance (AMR) resulting in treatment failure for bacterial infections (Carlet et al., 2014). Additionally, there are significant barriers to the creation and discovery of new antibiotics.

One major barrier to the development of new antibiotics is cost. Antibiotics take years to develop and generally have a limited time of effectiveness before resistance develops. In recent years there has been greater AMR seen in gram-negative bacteria (Gandra, Barter, & Laxminarayan, 2014). Increasing AMR has led to higher rates of morbidity and mortality in addition to the increasing economic costs to the patient (Gandra, Barter, & Laxminarayan, 2014). Therefore, pharmaceutical companies have begun focusing development efforts and financial resources towards alternative medications. The high cost of AMR is measured in more than just financial losses.

The Centers for Disease Control and Prevention (CDC) reports that two million Americans become ill with AMR diseases every year resulting in a minimum of 23,000 deaths. Further, the CDC estimates that the cost of AMR is $55 billion annually, with $20 billion in health care expenditures and $30 billion in productivity losses. (Dadgostar,

2019). The increasing rate of AMR is a world-wide situation that has forced governmental and non-governmental agencies to implement protocols guiding appropriate antibiotic use (Carlet et al., 2014).

In order to combat the costly issue of AMR, clinicians should only prescribe antibiotic therapy when clinically warranted. In fact, it is easy to misdiagnose a viral infection; furthermore, any delay in the initiation of antibiotic therapy for a bacterial infection may lead to increased morbidity and mortality (Bayram et al., 2015). Patients with non-specific clinical symptoms may be easily misdiagnosed without a rapid and definitive diagnostic test.

The gold standard for diagnosing bacterial infections is through use of blood cultures. Unfortunately, there is a minimum of 48 to 72 hours before definitive growth can identify the organism. This results in a delay of two to three days before the correct antibiotic can be initiated. Using a blood test that measures procalcitonin (PCT) would enhance care and allow health care providers to determine if an infection is bacterial possibly much sooner than blood cultures.

PCT is an inactive protein of the hormone calcitonin. PCT production is triggered by the detectability of the inflammatory response within two to four hours of onset of production. Production is suppressed unless there is an active bacterial infection in the body (Shiferaw, 2016). Due to its long half-life of 25-30 hours, PCT has greater advantages as a biomarker over the active form- calcitonin- with a short half-life. Therefore, PCT is a superior biomarker. Due to the predictability of its half-life and observable level in lab testing, PCT has implications for initiation and cessation of

antibiotics resulting in a reduction of AMR, morbidity, mortality, and healthcare costs (Shiferaw, 2016).

Purpose Statement

The purpose of this QI project was to evaluate the use of an evidence-based clinical guideline for PCT levels for antibiotic therapy de-escalation. The implemented clinical guideline was done at a long-term acute care hospital (LTACH) in a Midwestern state. Patients in LTACHs are at an increased risk of bacterial infections such as urinary tract infections and pneumonia. Current protocol is to obtain two sets of blood cultures, a urinalysis with reflex culture and a sputum culture when patients clinical picture changes (deviates). Based upon clinical picture, laboratory values, and clinician judgement, patients may be started on antibiotic therapy or a "wait and watch" approach may be taken until culture results return. The use of a PCT value along with clinical picture, vital signs, and a complete blood count may help the clinician to determine if antibiotics are warranted. The use of PCT could help to limit unnecessary exposure to antibiotic therapy and limit potential adverse reactions. Reduction in the use of antibiotics leads to organizational benefits which ultimately benefit the patient as well, such as the ability to reallocate scarce resources, reduction of hospital length of stay, and increase cost savings. A question was used to guide the literature review: What was the effect of using PCT as a diagnostic marker to identify bacterial infections in adult patients ages 18 and above?

Literature Review

The Cumulative Index of Nursing and Allied Health Literature (CINAHL), PubMed and Medline (EBSCO), Cochrane and Consumer Health Complete were searched. Key search terms used were *procalcitonin* AND *biomarker* AND *bacterial*

infections resulting in 1,643 articles. The search was refined to include peer reviewed journals, randomized controlled trials (RCT), systematic reviews, meta-analyses, and research articles in English from 1/1/2014 to 1/1/2021. Studies prior to 2014 were excluded. Inclusion criteria included studies consisting of male and female gender patients who were 18 years of age or older in an acute care hospital. Exclusion criteria included male or female under the age of 18 who were not in-patient at an acute care hospital. Duplicates were removed leaving 273 full text articles. Review of abstracts was done to ensure inclusion criteria were met. This resulted 36 articles. Full text articles were reviewed, resulting in 10 articles selected for inclusion in this literature review.

Bayram et al. (2015) investigated procalcitonin values and soluble triggering receptors that were expressed on myeloid cells-1 (sTREM-1) to be able to differentiate sepsis from noninfectious systemic inflammatory response syndrome (NI-SIRS). This enables clinicians to monitor the progression of those with sepsis. The study used a prospective data collection from 74 patients (41 individuals with NI-SIRS and 33 with sepsis) hospitalized in Celal Bayar University Hospital, Mansia, Turkey during an undisclosed timeframe. Blood was obtained from sepsis patients on days 0, 3, 4, 7, and 14 and then from NI-SIRS patients on days 0 and 3 (Bayram et al, 2015). Blood cultures revealed, gram-negative bacteria were the leading cause of sepsis in 60.6% of the cases (Bayram et al, 2015). The overall mortality rate equaled 18 patients in the sepsis group, these patients were divided between two units—ICU and surgical ward. The mortality occurrence was 16 and two patients respectively. The NI-SIRS group the mortality rate was nine patients (Bayram et al, 2015). Hence, the differentiation determined mortality early on by pointing out the sepsis v non-sepsis group.

Based upon the sepsis-related organ failure assessment (SOFA) scores, procalcitonin and sTREM-1 markers were evaluated to differentiate sepsis from NI-SIRS cases (Bayram et al, 2015). PCT and sTREM-1 markers results were higher in sepsis than NI-SIRS patients on days 0 and 3. Receiver operating characteristic (ROC) analysis was completed based upon SOFA scores, PCT, and sTREM-1 markers in the differentiation of sepsis and NI-SIRS. PCT and sTREM-1 values were not as significant as SOFA values in the prognosis in the early stages of sepsis. PCT was significant after day seven and sTREM-1 value after day four (Bayram et al, 2015). It was found that SOFA scores, PCT and sTREM-1 levels were significantly higher in patients with sepsis than in NI-SIRS patients (Bayram et al, 2015). PCT and sTREM-1 were important predictors in the outcomes of patients with sepsis. To be able to make an early diagnosis and the likely prognosis of patients suspected to have sepsis the researchers found that it requires serial monitoring of PCT and sTREM-1 values (Bayram et al, 2015).

Like the previous study, Jain et al. (2014) conducted a prospective observational study to determine if a PCT level could be used as an indicator of 28-day mortality rate of critically ill patients with suspected sepsis. The study took place in the Medical Intensive Care Unit in New Delhi, India from July 2011 to June 2013 and included 70 critically ill patients (Jain et al., 2014). Treatment was conducted based upon the Surviving Sepsis Campaign; antibiotic therapy guided by culture, infection source, and the healthcare provider (Jain et al., 2014). Patients who met sepsis criteria as defined by the 2001 International Sepsis Definitions Conference were enrolled (Jain et al., 2014).

Evaluation of this study utilized the Acute Physiology and Chronic Health Evaluation (APACHE II) score, Simplified Acute Physiology Score (SAPS II) and SOFA

scores on day-one (Jain et al., 2014). Additionally, (PCT) and C-reactive protein (CRP) levels on day 1, 7, and 28 following sepsis diagnosis were reviewed. Quantitative variables at admission were compared between survivors and non-survivors with Wilcoxon rank sum test and qualitative variables by chi-square test (Jain et al., 2014).

The PCT level was higher in patients with septic shock than severe sepsis and sepsis (Jain et al., 2014). The level of PCT fell significantly in survivors at 28 days with the median PCT 5.4 ng/mL on day-1 to 3.1 ng/mL on day-7 to 0.1 ng/mL on day-28. Upon admission, elevated PCT was a superior predictor of mortality than CRP. As with the Bayram et al. (2015) study use of serial PCT levels is recommended in conjunction with clinical judgment with history and physical examination.

Shehabi et al. (2014) investigated the effect of a low PCT cut-off for antibiotic therapy to correlate the relationship of PCT with the severity and mortality of sepsis. The study used a single-blind, randomized controlled trial with 400 patients in 11 Australian ICUs. The sample population included those who were at least 18 years of age suspected of having either a bacterial infection or sepsis and were expected to receive antibiotics for longer than 24 hours from March 2011 to December 2012 (Shehabi et al., 2014). The PCT level was measured daily and based upon Australian Antibiotics Therapeutic Guidelines and antimicrobial stewardship, antibiotics were stopped if criteria were met as outlined by the PCT de-escalation protocol (Shehabi et al., 2014).

Analysis included 196 PCT versus 198 standard care patients, and both groups included 93 patients with septic shock. The length of time to antibiotic initiation to cessation between groups was compared using a log-rank test and presented as median interquartile range (IQR) (Shehabi et al., 2014). The median IQR number of antibiotic

treatments were 9 versus 11 days; in patients with positive sputum cultures were 11 versus 15 days; with septic shock patients 9 versus 11 days; and the overall 90-day mortality was 35 versus 31 days, in PCT versus standard care (Shehabi et al., 2014). Results showed decreased mortality equal to four people. This study along with the Bayram et al. (2015) and Jain et al. (2014) provides strong evidence to show that use of PCT decreases overall patient mortality (Shehabi et al, 2014).

Unlike the previous studies Schuetz et al. (2017) conducted a systematic review assessing the length of antibiotic therapy with PCT monitoring in a large patient group with differing acuity. Randomized control trials (RCT) with 6708 participants from 26 trials in 12 different countries in primary care, emergency departments, medical floors and ICU with acute respiratory infections to receive antibiotics based on procalcitonin levels or in a control group from February 2017 to April 201 were included (Schuetz et al., 2017).

The systematic review showed 286 deaths in 3336 PCT-guided patients (8.6%) compared to 336 in 3372 controls (10.0%) (Schuetz et al., 2017). There was a significantly lower mortality with PCT-guided therapy. PCT guided therapy had a 2.4-day reduction in antibiotic exposure (5.7 versus 8.1 days) with lower risk of antibiotic related side effects. A sensitivity aggregate-data analysis of the 32 trials showed similar results (Schuetz et al., 2017).

Huang et al. (2017) conducted a systematic review and meta-analysis examining adult ICU patients that were managed with a PCT-guided algorithm or standard care. Thirteen trials with 5,136 patients were included with three clinical strategies: initiation, discontinuation, or a combination of antibiotic initiation and discontinuation strategies

(Huang et al., 2017). Analysis revealed that the PCT-guided antibiotic discontinuation strategy had fewer total days with antibiotics (mean = 1.66 days), longer antibiotic free days (mean = 2.26 days) and lower short-term mortality (Huang et al., 2017).

The review recommended the use of PCT to guide antibiotic discontinuation and reduce length of antibiotic exposure and lower short-term mortality (Huang et al., 2017). The meta-analysis supported the use of a low PCT level to discontinue antibiotic treatment and the use of antibiotic 1.67 days less and a lower short-term mortality compared to standard care. However, a baseline PCT value should not be used alone to determine antibiotic initiation. Further research is needed to determine the cut-off value of PCT for antibiotic discontinuation and to be able to generalize across multiple populations (Huang et al., 2017).

Townsend et al. (2018) used a PCT-guided algorithm for lower respiratory tract infection with clinical decision making and antibiotic stewardship for earlier antibiotic discontinuation in a 350-bed academic Baltimore, Maryland hospital. The electronic medical records were reviewed for control patients. A 30-day follow-up assessment using structured EMR review was conducted for both groups (Townsend et al., 2018).

Initial PCT was obtained in the emergency department then every 48 hours after being admitted to the floor or 24 hours for those who were admitted to ICU (Townsend et al., 2018). PCT results were only used as a guideline for discontinuation decisions. Antibiotic discontinuation was recommended if serial PCT values fell more than 80% from peak. In the PCT group antibiotic duration was lower than the control group with fewer patients discharged on antibiotics (Townsend et al., 2018).

The median antibiotic duration in the PCT (intervention) group was lower than in the control group (5 vs 6 days), total days of antibiotic therapy was significantly lower, and significantly fewer patients were discharged on antibiotics (37.4% vs 55.5%). There was no significant difference in PCT and control groups for adverse outcomes at 30 days. Hospital readmission at 30 days was 22.4% of PCT patients and 26.5% in control group. The study found that PCT-guided antibiotic therapy did effectively shorten antibiotic duration for LRTI (Townsend et al., 2018).

The literature review supports the concept of PCT levels as an effective diagnostic tool in combination with clinical judgment. It further demonstrates use of PCT as a better prognostic biomarker than CRP for bacterial infections. The use of PCT levels can limit unnecessary antibiotic therapy and decrease potential adverse reactions and AMR. However, PCT should not be used alone, nor should it stop the initiation of antibiotic therapy based upon one lab result when clinical judgment supports initiation.

Based upon the literature review the use of the Plan-Do-Study-Act (PDSA) evidence-based framework will be implemented to guide this QI project. The aim of this project is to increase identification of bacterial infections with the addition of the PCT test as compared to the previous infectious disease (ID) workup. Primary outcome measures analyzed included the average antibiotic length of time, the number of antibiotics used and the number of times elevated PCT correlated with positive blood cultures. The QI project was implemented by the LTACH clinicians and monitored by the primary investigator.

Methods

Design

This QI project utilized a prospective observational design by implementing a PCT level to the current ID workup. Quantitative data was collected via prospective chart review and included the number of positive PCT levels obtained versus blood cultures, urine culture, and sputum cultures. In addition, data was collected regarding the average length of time a patient was on an antibiotic, the number of different antibiotics used and the number of times that positive cultures correlated with an elevated PCT level. Additionally, data collected included time until diagnosis of bacterial infection after ID work-up was collected.

Setting

This QI project took take place in a LTACH specializing in vent-weaning, long-term antibiotic therapy, and wound care therapy. The unit averages 23 critical care patients daily with a minimum 21-day length of stay. The hospital, located in a midwestern state has approximately 100 employees and is part of a large system of LTACH hospitals located throughout the United States. The hospital did not use PCT in the ID work-up prior to project implementation.

Sample

This QI project used a purposeful sample drawn based on the ID work-up criteria. Patients who did not meet criteria for ID work-up were excluded along with patients younger than age 18 and not admitted to the hospital. All medical records of patients fitting the above criteria from January 4, 2022, to March 31, 2022, were included in the analysis. The use of a unique alphanumeric identifier was implemented to de-identify patient data. This identifier consisted of the last name initial followed up first name initial with the six-digit date of ID work-up (month/day/two-digit year). A master list containing

coded identifiers and coordinating patient names with date ID work-up began was stored on the project mentor's password protected hospital provided computer.

Approval Processes

Formal, written approval was sought and obtained from the hospitals Critical Care Director on October 7, 2021. and given university IRB approval in December 2021. The project protocol was evaluated and determined be a QI project and therefore, not be human-subjects research. Because labs were routinely drawn for each patient that met inclusion criteria, no risk to the patient was foreseen. Potential patient benefit included potential decreased antibiotic exposure. No ethical considerations were noted.

Data Collection/Analysis

De-identified patient data was collected prospectively from chart review. Demographic variables included age, gender, ethnicity and admitting diagnosis. Patient data also included PCT levels, length of antibiotic use (in days), number of antibiotics used, urine culture results, sputum culture results, and blood culture results. Data was analyzed using descriptive statistics for measure of central tendency and use of Wilks Lambda analysis for test of association. SPSS Statistics was used to analyze the length of antibiotic use, number of antibiotics used, time of identification of bacterial infection after ID work-up, and the number of times positive PCT levels correlated to a positive culture.

Procedure

Adding a PCT level to the current ID work-up was a QI project selected by the Doctor of Nursing Practice (DNP) candidate in corroboration with the pulmonary critical care Certified Nurse Specialist and was approved by the Critical Care Director. Education

was created and distributed to all clinicians practicing in the LTACH instructing the inclusion of a PCT level when doing an ID work-up and a PCT level again on day three and five prior to implementation. After the project was implemented in January 2022, PCT levels were included along with patient presentation, WBC counts two-days before ID work-up, one-day before then again on day 1, 3, and 5 with blood/urine/sputum culture results when evaluating the initiation/cessation of antibiotic therapy and length of antibiotic therapy. Data collection occurred for 12 weeks after initiation of the implementation. The data was downloaded from the EMR in April of 2022 and transferred to an Excel spreadsheet for data analysis.

Results

Demographics

The sample included 22 patients aged 46 to 83 years, with a mean of 65.68 years (*SD*=9.67) (Table 1). There were 13 females (59.09%) and nine males (41.91%) participants (Table 1). The only ethnicity was Caucasian. The admitting diagnoses were 10 Acute hypoxic respiratory failure due to Covid pneumonia (45.45%), four Acute on chronic hypoxic and hypercapnic respiratory failure COPD exacerbation (18.18%), two Acute hypoxic respiratory failure after cardiac arrest (9.09%), two Acute hypoxic respiratory failure after bowel perforation (9.09%), two Acute hypoxic respiratory failure due to intracranial diffuse brainstem hemorrhage (9.09%), and two Acute hypoxic respiratory failure due to Ischemic stroke (9.09%) (Table 1, Appendix C).

Procalcitonin

A one-way repeated measured analysis of variance (ANOVA) was conducted to evaluate the null hypothesis of the effect of PCT as a diagnostic marker to identify

bacterial infections in adult patients 18 and above. PCT was measured on day-1, day-3, and day-5. Then WBC counts were retroactively collected two days before ID work-up, one day before infection onset, with WBC counts collected on day-1, day-3, and day-5. The results of the ANOVA indicated a significant time effect of WBC, (Wilks' Lambda = .379, $F(4, 17) = 6.960$, $p < .01$, $n^2 = .621$). Thus, there is significant evidence to support the positive relationship between elevated PCT levels and positive cultures (Table 4). The results of the ANOVA indicated a significant time effect of PCT, (Wilks' Lambda = .727, $F(2, 20) = 3.566$, $p < .01$, $n^2 = .273$). Hence, over time the level of PCT decreases showing a correlation with a reduction of WBC count (Table 5).

A retrospective review of the ID work-up examined WBC counts. A reviewal identified the mean WBC count two-days before the ID work-up of 11.224 (SD=3.5665), one-day before with a mean of 12.867 (SD=4.7381), day-1 post ID work-up with a mean of 17.276 (SD=7.0034), day-3 post ID work-up a with a mean of 13.305 (SD=5.1299) and day-5 post ID work-up with a mean of 11.343 (SD=4.7777) (Table 2, Appendix A). PCT levels were simultaneously collected with WBC counts. On day-1 post ID work-up the mean PCT was .4752 (SD=.62030), day-3 post ID work-up with a mean of .3371(SD=.45256), and day-5 post ID work-up with a mean of .2252 (SD=.28365) (Table 3, Appendix B). Hence, there is a correlation between both WBC and PCT levels decreasing with the initiation of antibiotics.

Discussion

Implementation of this QI effort accomplished the purpose to increase identification of bacterial infections with the addition of a PCT test as compared to the previous ID work-up. The primary outcome measures analyzed included

the average length of time patient was on antibiotics, the average number of different antibiotics used, the average time until confirmation of bacterial infection after ID work-up.

Serum PCT levels will rise within two to four hours of an inflammatory stimulus, then peaking within 24-48 hours (Shiferaw, 2016). PCT levels then will quickly decline at a predictable rate. After reaching the peak, levels will then decline about 50 percent every 1 to 1.5 days. This correlation was seen in the QI project with the PCT levels obtained from the sample population (Shiferaw, 2016).

The implemented PCT clinical guideline allowed for faster identification of bacterial infections with a (mean=1.74 days) vs. the standard of 48-72 hours with blood cultures. Positive cultures correlated with an elevated PCT level 14 times throughout the QI project. The PCT and cultures were negative eight times throughout the project. Therefore, this means that eight patients who started on antibiotics due to clinical presentation were able to be de-escalated preventing further contribution to AMR. The average length of time patients were on antibiotics was (mean=8.909 days) with an average number of different antibiotics used was (mean=2.14). The use of continual monitoring of PCT allowed to de-escalate antibiotic use when the PCT value decreased to negative.

Implications for Practice

PCT helps to distinguish bacterial infection from other causes of infection or inflammation. In patients with LRTIs and sepsis, PCT can be used with clinical judgement for guiding antibiotic therapy and resolving diagnostic uncertainty. The collection of serial PCT levels with WBC counts on day-1, day-3, and day-5 can

determine the continual need of antibiotic therapy based upon clinical improvement and serial PCT levels. The use of PCT as a guide for antibiotic therapy provides clinicians with another investigative tool in the decision process for the initiation and cessation of antibiotic therapy for patients with suspected bacterial infection. This allows for reduction of inappropriate antibiotic use, reducing hospital admissions, decreasing length of hospitalization, limiting potential adverse reactions, reallocation of scare resources, and increase cost savings to a strained healthcare system and patients.

Recommendations

It is recommended that the LTACH continue with the use of a PCT level with the current ID work-up. Then if the PCT level is positive, antibiotic initiation should occur with repeat PCT and WBC counts on day-3 and day-5 to monitor whether antibiotic therapy should be escalated or de-escalated. The use of PCT levels is an effective diagnostic tool in combination with clinical judgment. The use of PCT levels can limit unnecessary antibiotic therapy and decrease potential adverse reactions and AMR. However, PCT should not be used alone, nor should it stop the initiation of antibiotic therapy based upon one lab result when clinical judgment with history and physical examination supports initiation.

It should be noted that there are limitations to this QI project due to the limited sample size which then limited the ethnicity of the population being collected. A longer implementation period of the QI project than 12-weeks would allow for the collection of more data results likely increasing the population ethnicity. A larger sample size in a bigger institution would also compensate for this limitation. The facility being a LTACH

limits sample size as this population has hospitalization lengths ranging from 21-120 days.

Conclusion

In this QI effort, implementation of PCT levels in the ID work-up in patients aged 18-years and older in an LTACH identified bacterial infections rapidly. Monitoring of serial PCT levels allows for evaluation of antibiotic acceleration or de-escalation swiftly when PCT levels decline. With the limited sample size of this project, future PDSA cycles and data collection should occur to continue analysis of PCT value to antibiotic de-escalation.

This QI project exemplifies the role of the DNP in practice. The DNP is a terminal degree, a unique merging of fundamental Nightingale principles with medical science to improve health outcomes while fulfilling human needs . A DNP prepared provider has the honor and responsibility to make continuous significant impact on the quality and efficiency of the healthcare system by practicing with the best evidence-based practice. DNPs' must advocate for their patient by continuing to push for health policies that are in the best interest of their patient then implementing and evaluating their effectiveness. This QI project implemented a biomarker tool to the current ID work-up resulting in faster identification of bacterial infections and allowing for de-escalation of antibiotics when unwarranted. Hence, improving patient outcomes.

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Apppendices/Tables

Table 1

Demographic Characteristics of Participants, n = 22

Characteristics	n	%	M	SD
Age	22		65.68	9.67
Gender				
Female	13	59.09%		
Male	9	40.91%		
Race/Ethnicity				
Caucasian	22	100%		
Admitting Diagnosis				
Acute hypoxic resp fail 2/2 Covid pneumonia	10	45.45%		
A/C hypoxic/hypercapnic resp fail 2/2 COPD exacer.	4	18.18%		
Acute hypoxic resp fail after cardiac arrest	2	9.09%		
Acute hypoxic resp fail after bowel perforation	2	9.09%		
Acute hypoxic resp fail 2/2 intracranial diffuse brainstem hemorrhage	2	9.09%		
Acute hypoxic respiratory failure due to Ischemic stroke	2	9.09%		

Note. Output obtained using IBM SPSS Statistics for Windows, version 27.0

Table 2

White Blood Cell Count Statistics (n=22)

	Mean	SD	N
WBC count 2-days before ID work-up	11.224	3.5665	22
WBC count 1-day before ID work-up	12.867	4.7381	22
WBC count Day-1 post ID work-up	17.276	7.0034	22
WBC count Day-3 post ID work-up	13.305	5.1299	22
WBC count Day-5 post ID work-up	11.343	4.7777	22

Note. Output obtained using IBM SPSS Statistics for Windows, version 27.0

Table 3

Procalcitonin Statistics (n=22)

	Mean	SD	N
PCT Day-1 post ID work-up	0.4752	0.62030	22
PCT Day-3 post ID work-up	0.3371	0.45256	22
PCT Day-5 post ID work-up	0.2252	0.28365	22

Note. Output obtained using IBM SPSS Statistics for Windows, version 27.0

Table 4

Multivariate Tests WBC[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Wilks' Lambda	0.379	6.960	4.000	18.000	0.002	0.621	27.840	0.971

a. Design: Intercept Within Subjects Design: Time. c. Computed using alpha = 0.05

Note. Output obtained using IBM SPSS Statistics for Windows, version 27.0

Table 5

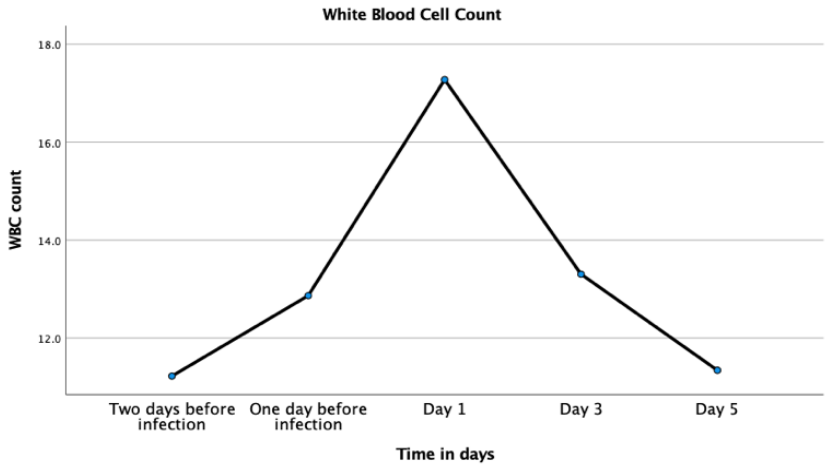
Multivariate Tests PCT[a]

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Noncent. Parameter	Observed Power[c]
Time	Wilks' Lambda	0.727	3.366	2.000	20.000	0.048	0.273	7.131	0.590

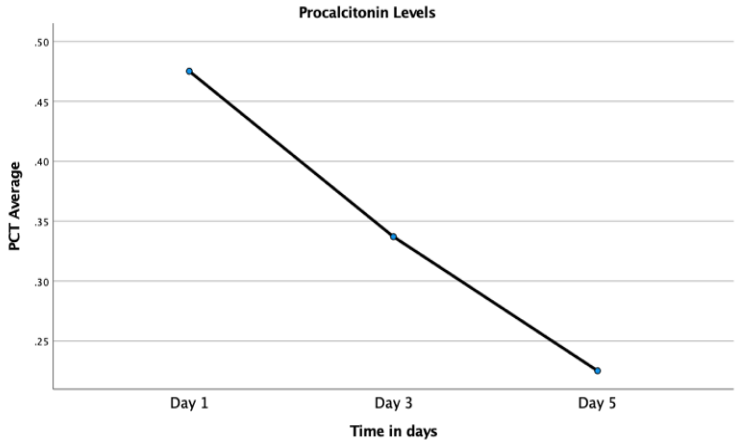
a. Design: Intercept Within Subjects Design: Time. c. Computed using alpha = 0.05

Note. Output obtained using IBM SPSS Statistics for Windows, version 27.0

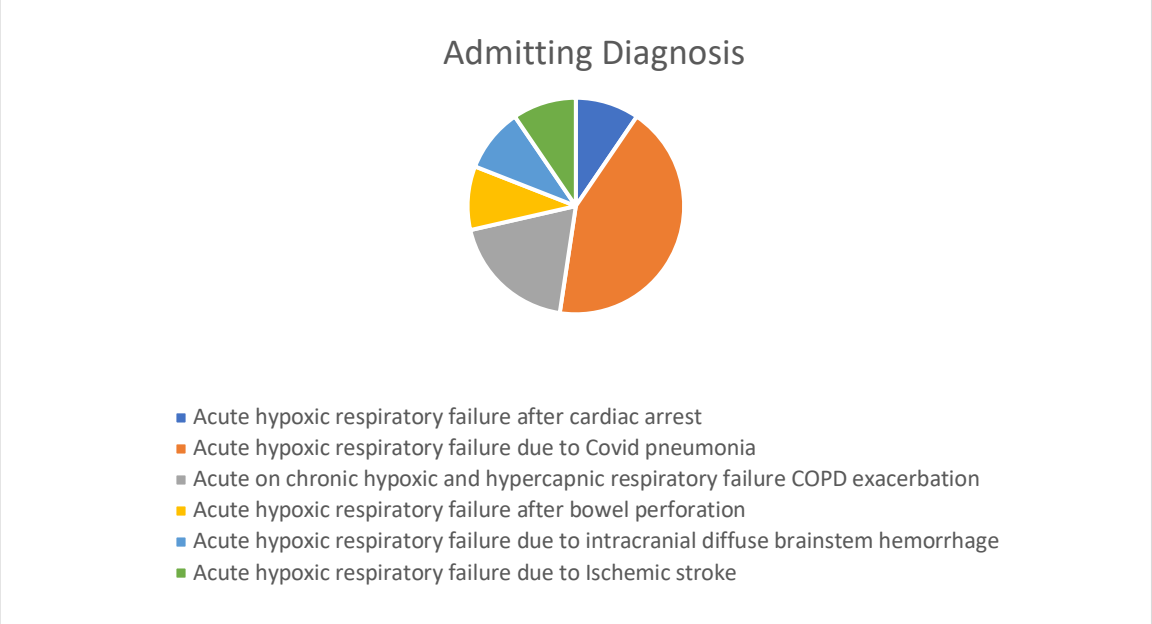
Appendix A



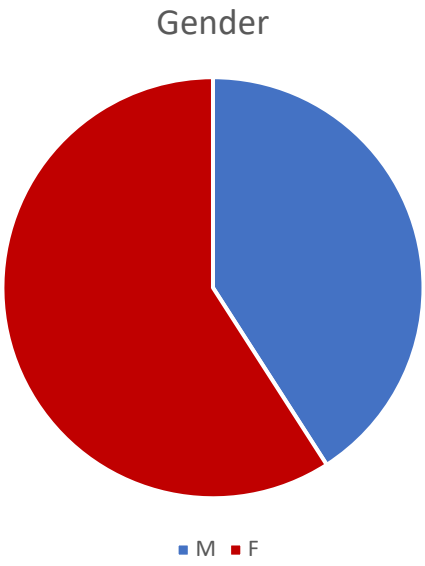
Appendix B



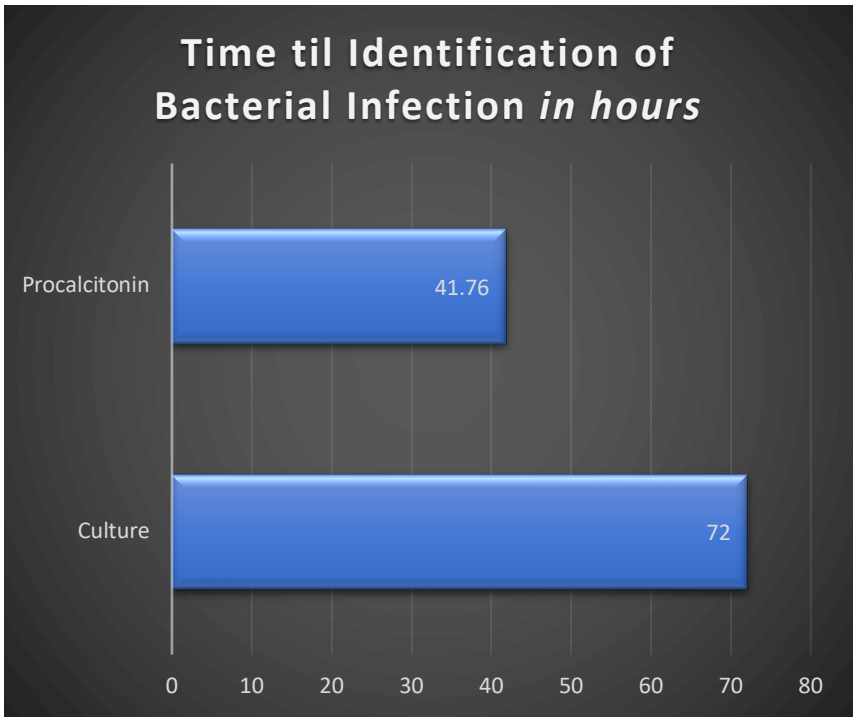
Appendix C



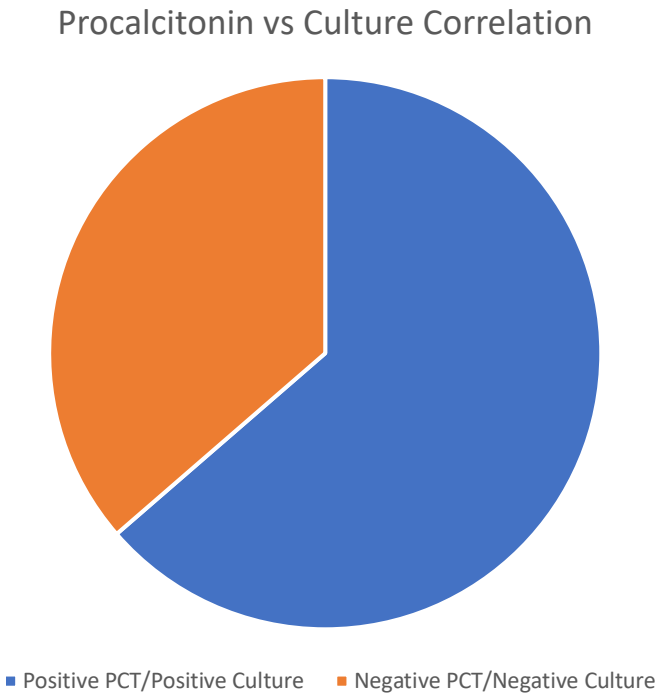
Appendix D



Appendix E



Appendix F


Procalcitonin vs Culture Correlation
Positive PCT/Positive Culture
Negative PCT/Negative Culture